

# Potential of Flavocide™ as a new grain protectant to manage major resistant stored grain pests: an Australian case study

Dr Manoj Nayak

Leader, Postharvest Grain Protection Team

Department of Agriculture and Fisheries, Queensland, Australia

12<sup>th</sup> Conference of the IOBC-WPRS - Integrated Protection of Stored Products, Pisa, Italy 4th - 6th September 2019

# Outline

- **Background**
- **Australian grain industry at a glance**
- **Major stored product pests**
- **Current pest management strategies**
- **Brief overview - Flavocide™**
- **Research methodology**
- **Results**
- **Summary**
- **Future direction**

# Background

## Bio-Gene Technology Ltd - funded Project (2016-2019)

*“To develop Flavocide™ as a suitable grain protectant to manage resistant stored grain pests in Australia”*

## Research Team

- **Department of Agriculture and Fisheries**

- Manoj Nayak, Greg Daglish, Rajeswaran Jagadeesan, Philip Burrill, Valerie Byrne, Hervoika Pavic

- **Bio-Gene Technology Ltd**

- Peter May, James Wade

# Australian grains industry at a glance...

- substantial contributor to Australian economy
- cereal grains, oilseeds and pulse crops - \$18 billion
- 29% of farm production/ 30% value of farm export
- up to 80% of grain exported
- 'Nil tolerance' applicable for live insects



# Major stored product pests



Lesser grain borer,  
*Rhyzopertha dominica* (RD)



Rusty grain beetle  
*Cryptolestes ferrugineus* (CF)



Rust-red flour beetle  
*Tribolium castaneum* (TC)



Rice weevil,  
*Sitophilus oryzae* (SO)



Sawtoothed grain beetle  
*Oryzaephilus surinamensis* (OS)

# Current insect pest management

## Chemical treatments

*Disinfest* - Fumigants (80%)

*Protect* - Protectants (20%)

*Structural treatments* (hygiene)

## Non-chemical

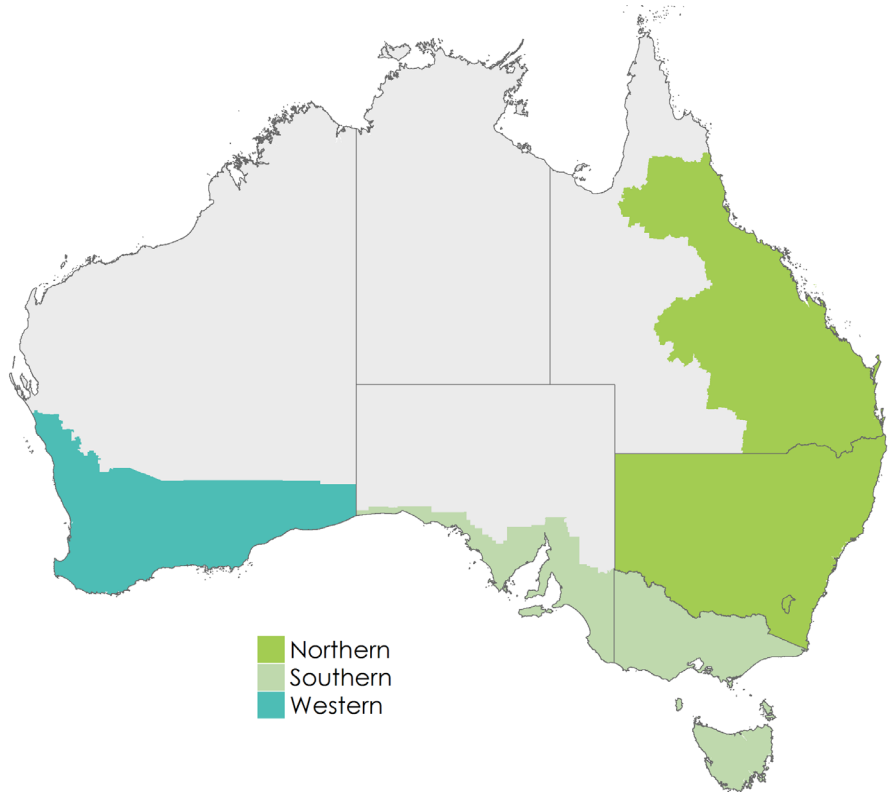
*Aeration cooling*

## Resistance management

*Monitoring*

*New protocols*

*Developing alternative treatments*



# Grain protectants used

- Chlorpyrifos-methyl (resistance: **RD, OS**)
- Fenitrothion, Pirimiphos-methyl (resistance: **RD**)
- S-methoprene (resistance: **RD, SO**)
- Chlorpyrifos-methyl + S-methoprene (resistance: **RD**)
- Deltamethrin/PBO (resistance: **SO**)
- Spinosad (only controls **RD**)

**Need for combination treatments to control range of resistant pests**

# Brief overview - Flavocide™

**β-triketones** — class of biologically active natural plant compounds occurring in Myrtaceae (e.g. myrtles, eucalypts)

- Natural oil containing compound **tasmanone**
  - Bio-Gene trade name: **Qcide™**
- Synthesised nature-identical compound **flavesone**
  - Bio-Gene trade name: **Flavocide™**
- Insecticidal activity against a range of pest types
- Novel mode of insecticidal action
- Potential for control of resistant species

# Research objectives

## Objective 1

Establish a dose to control susceptible and resistant strains

- *Range-finding bioassays against RD*
- *Test TC, CF, SO and OS at effective dose*
- *Criteria: adult mortality and progeny suppression*

## Objective 2

Determine potential partners for a combination treatment

- *Chlorpyrifos-methyl*
- *Deltamethrin (K-Obiol – Deltamethrin plus PBO)*

## Objective 3

Determine residual efficacy in wheat over time at effective dose

- *up to 9 months*

# Methodology – Laboratory experiments

## • Treatment

- Flavocide 500EW (500g/L flavesone in oil-in-water emulsion)
- Deltamethrin/PBO Combo (50g/L deltamethrin/ 400g/L PBO)
- Chlorpyrifos-methyl (500g/L chlorpyrifos-methyl)
- Dilutions made in distilled water

## • Grain

- Insect-free organic wheat (no treatment history)
- Moisture content after treatment – 12%

## • Bioassay

- @ 10 mL per kilogram of wheat in glass jars
- 50 adults (1-3 wk) released (3 reps)
  - a **susceptible** strain used alongside a **resistant** strain
- Left in controlled environment room
  - 25°C and 55% r.h. (SO, OS)
  - 30°C and 55% r.h. (RD, TC, CF)

# Resistant status of pest strains used

## ***R. dominica***

- QRD1440 - resistant to OP protectants, pyrethroids

## ***T. castaneum***

- QTC279 - resistant to malathion, bioresmethrin

## ***C. ferrugineus***

- QCF73 – resistant to phosphine

## ***O. surinamensis***

- QOS202 - resistant to fenitrothion, chlorpyrifos-methyl

## ***S. oryzae***

- QSO393 – resistant to fenitrothion

# Key criteria for success

## Adult mortality

Adults exposed to treated and untreated (control) grain for 14 days

- *grain sieved; mortality recorded*
- *live and dead insects removed*
- *grain returned to experimental jars*
- *left in controlled env. room for 6 weeks*



## Progeny suppression

F1 Adult progeny after 6 weeks

- *progeny counted*
- *suppression determined by comparing progeny numbers in treated and untreated (control) grain*

# Range-finding: Flavocide vs. susceptible and resistant strains of *R. dominica*

Treatment (ppm)	Strain	% Adult mortality	% Progeny suppression
25	Susceptible	100	100
	Resistant	30	30
50	Susceptible	100	100
	Resistant	95	100
60	Susceptible	100	100
	Resistant	100	100
75	Susceptible	100	100
	Resistant	100	100
100	Susceptible	100	100
	Resistant	100	100

- Pilot - 25 ppm effective - sus.
- 25 ppm not effective - resist.
- 50 ppm - complete suppr. of progeny, but adults survive
- 60 ppm – achieves complete control of adults and progeny

# Efficacy of two selected Flavocide doses against resistant strains of five key species

Species	Treatment (ppm)	% Adult mortality	% Progeny suppression
<i>R. dominica</i>	25	57	89
	60	100	100
<i>T. castaneum</i>	25	0	17
	60	0	36
<i>C. ferrugineus</i>	25	3	77
	60	62	100
<i>O. surinamensis</i>	25	0.7	61
	60	15	100
<i>S. oryzae</i>	25	0.7	6
	60	0.7	29

- 25 and 60 ppm - not effective vs **TC, SO**
- 25 and 60 ppm - low efficacy vs adults - **CF, OS**
- 60 ppm - complete suppr. of progeny – **RD, CF, OS**
- **Not suitable** as ‘stand alone’ treatment to control resistant strains of all pest species

# Effect of Flavocide in combination with chlorpyrifos-methyl against resistant strains

Pest species (resistant strain)	30 ppm Flavocide plus				60 ppm Flavocide plus			
	5 ppm CM		10 ppm CM		5 ppm CM		10 ppm CM	
	Adults	F1	Adults	F1	Adults	F1	Adults	F1
<i>R. dominica</i> (QRD1440)	N	N	N	Y	Y	Y	Y 99.3	Y
<i>T. castaneum</i> (QTC279)	Y 99.3	Y	Y	Y	Y	Y	Y	Y
<i>C. ferrugineus</i> (QCF73)	Y	Y	Y	Y	Y	Y	Y	Y
<i>O. surinamensis</i> (QOS202)	N	N	N	N	N	Y 99.8	N	Y
<i>S. oryzae</i> (QSO393)	Y	Y 99.9	Y	Y	Y	Y 99.9	Y	Y

Flavocide 60 ppm - highly effective vs. F1 in combination with Chlorpyrifos-methyl

# Overview of results of combination of Flavocide & chlorpyrifos-methyl vs. resistant strains

- 30 ppm Flavo. + 5 ppm Chlor-methyl - not effective **RD, OS**
- 30 ppm Flavo. + 10 ppm Chlor-methyl
  - not effective against **OS**
  - not effective against **adults of RD**
- 60 ppm Flavocide + 5 ppm/10ppm Chlorpyrifos-methyl
  - controls all spp. **except adults of OS**
- Flavocide **at 60 ppm**
  - **highly effective** as a combination **with Chlorpyrifos-methyl**

# Effect of Flavocide in combination with deltamethrin (+PBO) against resistant strains

Pest species (resistant strain)	30 ppm Flavocide plus				60 ppm Flavocide plus			
	0.5 ppm K-Obiol		1.0 ppm K-Obiol		0.5 ppm K-Obiol		1.0 ppm K-Obiol	
	Adults	F1	Adults	F1	Adults	F1	Adults	F1
<i>R. dominica</i> (QRD1440)	N	N	N	Y	Y	Y	Y	Y
<i>T. castaneum</i> (QTC279)	N	N	N	N	N	N	N	N
<i>C. ferrugineus</i> (QCF73)	Y	Y	Y	Y	Y	Y	Y	Y
<i>O. surinamensis</i> (QOS202)	N	Y	N	Y	Y	Y	Y	Y
<i>S. oryzae</i> (QSO393)	N	N	N	N	N	N	N	N

Flavocide 60 ppm highly effective vs. 3 spp in combination with deltamethrin (+PBO)

# Overview of results of combination of Flavocide and deltamethrin (+PBO) vs. resistant strains

- 30 ppm Flavocide + 0.5 ppm deltamethrin (+PBO)
  - not effective against RD, TC and SO
  - only effective against CF and progeny of OS
- 30 ppm Flavocide + 1 ppm deltamethrin (+PBO)
  - not effective against TC and SO
  - only effective against CF and progeny of RD and OS
- 60 ppm Flavocide + 0.5 ppm/1ppm deltamethrin (+PBO)
  - not effective against TC and SO
- Flavocide at 60 ppm
  - highly effective (3 spp) as a combination with deltamethrin (+PBO)

# Methodology – long-term residual studies

## • Treatment

- Flavocide 500EW (500g/L flavesone)
- dilutions made in distilled water – 60, 90, 120 ppm
- applied @ 1litre/tonne (through nozzles in auger)

## • Grain

- freshly harvested insect-free untreated wheat
- treated grain put into 1 tonne bulk bags

## • Bioassay

- bulk bags of treated and control (water only) grain stored in shed
- samples taken and stored in laboratory for bioassays at 0, 1, 2, 3, 6, 9 and 12 mo
- samples from shed taken at similar time intervals to the lab for bioassays



# Residual efficacy (% mortality) against resistant *R. dominica* adults

Storage Period (months)	Location	60 ppm	90 ppm	120 ppm
0	Laboratory	99.3	100	100
	Field	99.3	100	100
1	Laboratory	90.0	99.3	99.3
	Field	87.9	99.3	100
2	Laboratory	49.3	87.3	99.3
	Field	64.0	93.9	99.3
3	Laboratory	17.3	59.3	96.7
	Field	25.3	71.8	93.3
6	Laboratory	6.0	19.3	78.0
	Field	4.0	49.3	82.7

- Laboratory data matched well with field data
- Efficacy against adults dropped significantly over time across all 3 doses

# Residual efficacy (% suppression) against resistant *R. dominica* progeny

Storage Period (months)	Location	60 ppm	90 ppm	120 ppm
0	Laboratory	100	100	100
	Field	100	100	100
1	Laboratory	100	100	100
	Field	100	100	100
2	Laboratory	99.8	100	100
	Field	99.3	100	100
3	Laboratory	99	99.5	100
	Field	99.2	100	100
6	Laboratory	96.3	99.5	100
	Field	96.7	100	100

- Laboratory data matched well with field data
- Complete progeny suppression achieved at all rates up to 3 months
- Complete progeny suppression achieved at rates of 90 and 120 ppm consistently up to 6 months

# Summary

- Flavocide has great potential to manage resistant pests
- Flavocide alone may need doses higher than 60ppm for >6 months residual efficacy
- More effective against progeny suggesting sub-lethal effects on adult fecundity or on other life stages
- Potential for use in combination with other products to broaden scope of activity & improve efficacy

# Future research...

- **Extend the 'stand alone' residual study to 9 months**
- **Extend residual testing to other storage pest species**
- **Residual efficacy testing with combination treatments - deltamethrin & chlorpyrifos-methyl**
- **Efficacy on other commodities - barley, sorghum, maize, rice**



# The Research Team



# Acknowledgements

- **12<sup>th</sup> IOBC-WPRS Organisers (Profs Pasquale, Barbara)**
- **BioGene Technology Ltd**

# Controlled Atmosphere and Fumigation Conference (CAF) - 2024 in Cairns?



# Thank you

**For more information, please email  
[manoj.nayak@daf.qld.gov.au](mailto:manoj.nayak@daf.qld.gov.au)**